Marine Turtle Monitoring and Tagging Program.
Caño Palma Biological Station, COTERC.
Barra del Colorado Wildlife Refuge, Costa Rica.

Green (*Chelonia mydas*) 2017 Season Report

Submitted to:
Ministerio de Ambiente y Energía de Costa Rica (Costa Rican Ministry of Environment and Energy) (MINAE)
Canadian Organization for Tropical Conservation and Rainforest Conservation (COTERC)

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Cover picture: Green turtle (*Chelonia mydas*)/ Jane Mariotti
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**Acronyms**

CCLmin: Longitud Curva del Caparazón (mínima).
CCWmax: Anchura Curva del Caparazón (máxima).
CP: Caño Palma.
EBCP: Estación Biológica Caño Palma
ENC: Encuentro.
GPS: Sistema de Posicionamiento Global.
HLF: Media luna: la tortuga sale del mar pero no pone huevos.
NST: Nido.
OTH: Agujero de una antigua marca.
OTN: Rasgadura de una antigua marca.
REC: Nuevo registro – la tortuga no tenía marcas anteriores.
REM: Re-emergente – la tortuga tenía alguna marca previa.
REN: Re-anidadora – la tortuga ya había anidado en Playa Norte esta temporada.
TN: Nido triangulado.
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Summary

The official dates for Green and Hawksbill season are 1st June – 31st October. Nevertheless, the first green turtle nest was recorded on March 24th and the last one on December 9th, therefore, this report will discuss that time period. Night patrols for all the species were carried out from March 29th until October 29th, and the morning census started on March 25th and continued until December 17th.

Survey effort

- Total hours spent on night patrol was 1531 hours and 10 minutes, with a mean per night of 7 hours and 11 minutes.
- Total hours spent on morning census was 850 hours and 45 minutes, with a mean per day of 3 hours and 10 minutes.

Nesting activity — Green Turtle

- The first nest of the season was laid on March 24th, and the last one was on December 9th.
- A total of 333 nests were recorded between March 24th and December 9th.
- A total of 832 halfmoons were recorded between March 13th and October 24th.
- Of the nesting green turtles, 39% (130 out of 333) were encountered by our patrol teams on patrol:
  - 58 RECs.
  - 47 REM
  - 25 RENs
- Teams encountered the 15.3% (128 out of 832) of the turtles during halfmoons.
- Of the 333 nests recorded, 93 were triangulated (28%).
- Three dead turtles were found, 20 lifted turtle tracks, and two flipped turtles.

Nesting activity outside the transect

- Two nests and three halfmoons were recorded north of mile 3 1/8.
- All the activity was recorded with the turtle absent.

Nest Success.

- The mean number of yolked eggs was 98±41.57 (Mean ± SD; range: 6 – 171).
- The mean number of yolkless eggs was 0.41±0.86 (Mean ± SD; range: 0 – 2).

Of the 93 triangulated nests:
  - 42 remained as natural for the whole incubation period.
  - Seven were recorded as wet at some point during incubation.
  - All three flagging points were removed (by unknown persons) at some point in the incubation of two nests. One of these was lost, the other one was later found by hatchling tracks.
- No nest was recorded as flooded.
- No nest was eroded.
- 17 nests were predated or partially predated at some point during incubation.
- Five nests were not found when the excavations were performed.
- 23 nests were poached, partially poached or suspected of being altered by human activity.

Biometrics
- The mean minimum Curved Carapace Length (CCLmin) was 105.43 ± 5.67 cm (Mean ± SD; range: 92.1 – 121.9 cm) (n=124).
- The mean maximum Curved Carapace Width (CCWmax) was 95.57 ± 5.58 cm (Mean ± SD; range: 85.8 cm – 116.2 cm) (n=122).

Nesting Activity – Hawksbill Turtle
- The first nest of the season was laid on March 21st and the last one on October 27th.
- A total of 71 nests were recorded between March 21st and October 27th.
- A total of 93 halfmoons were recorded between April 21st and November 7th.
- Of the nesting hawksbill turtles 52.1% (37 out of 71) were encountered by our patrol teams on patrol:
  - 20 RECs.
  - 8 REM
  - 8 RENs
- Teams encountered the 8.6% (8 out of 93) of the turtles during halfmoons.
- Of the 71 nests recorded, 28 were triangulated (39.44%).
- Four lifted turtle tracks were found.

Nest Success
- The mean number of yolked eggs was 147.69 ± 36.05 (Mean ± SD; range: 71 – 95).
- No record of yolkless eggs.

Of the 28 triangulated nests:
- 13 remained as natural for the whole incubation period.
- No nest was recorded as wet.
- No nest was recorded as flooded.
- No nest was eroded.
- Nine nests were predated or partially predated at some point during incubation.
- One nest was not found when the excavation was performed.
- Five nests were poached or partially poached.
Biometrics

- The mean minimum Curved Carapace Length (CCLmin) was 87.55 ± 3.78 cm (Mean ± SD; range: 81.7 – 94.3 cm) (n=32).
- The mean maximum Curved Carapace Width (CCWmax) was 78.85 ± 3.57 cm (Mean ± SD; range: 70.7 cm – 85.4 cm) (n=27).
Introduction

This report focuses exclusively on the nesting activity of the Green (*Chelonia mydas*) and Hawksbill (*Eretmochelys imbricata*) turtles. For more information about the nesting activity of the Leatherback turtle (*Dermochelys coriacea*) please refer to the Leatherback Season Report 2017.

Caño Palma Biological Station (CPBS) was founded in 1991, and the Canadian Organization for Tropical Education and Rainforest Conservation was established shortly afterwards as a non-profit organization in Canada. The CPBS invites volunteers, interns and researcher to study different taxonomic groups and also encourage them to participate in the different activities of the station. This report focuses on the results from the 2017 Green season of the Marine Turtle Monitoring and Tagging Program.

In the Northern Caribbean Coast of Costa Rica, in the Tortuguero zone, four species of marine turtles nest: leatherback (*Dermochelys coriacea*), green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), and loggerhead (*Caretta caretta*) (Márquez, 1990; Ernst and Barbour, 1989). All these species have been recorded on our study site Playa Norte.

The Marine Turtle Monitoring and Tagging Program started in 2006, its main objectives are:

- Conduct research and collect data on nesting sea turtles on Playa Norte
- Assess the health status of nesting females.
- Educate the public (local community and tourists) about sea turtle biology and conservation.
- Deter poaching by maintaining a presence on the beach

Data are collected following standardized protocols. This report provides detailed information on the methods used and the results obtained from data collection in the 2017 Leatherback nesting season. Protocols were utilized for their comparability to past year’s data and data of other projects. This enables a greater understanding though the identification of trends and places the data collected at Playa Norte in a wider context.

**Green Turtle (*Chelonia mydas*)**

All hard-carapace marine turtles belong to the family Cheloniidae. This family is believed to have branched 50 million years ago into the six species alive today: green, hawksbill, loggerhead, Kemp’s ridley, olive ridley, and flatback (Spotila, 2004). Greens are the slowest maturing of the marine turtle species; depending on the population the estimated age to reach sexual maturity is between 25-50 years (Spotila, 2004).

Greens are distributed across the tropics and sub-tropics and migrate hundreds of miles between feeding and breeding grounds (Eckert et al., 2001). It is known that females return to the natal beach from which they hatched in order to nest (Eckert et al., 2001). It is widely accepted that they achieve this navigational feat through geomagnetic imprinting (Eckert et al., 2001).

The largest green turtle rookery in the Western hemisphere is in Tortuguero, Costa Rica (approximately seven miles south of Playa Norte) (STC, 2015). It is estimated that 17,402–37,290 females nest annually at this location (Troëng & Rankin, 2005). See Table 1a for characteristics of this species.
Table 1a. Characteristics of the green turtle (Chelonia mydas). (Adapted from Chacón et al., 2007)

<table>
<thead>
<tr>
<th>Scientific name: Chelonia mydas</th>
<th>Common name: Green turtle.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average length (CCL)</td>
<td>88.6 cm (Pacific population), 104.6 cm (Caribbean population).</td>
</tr>
<tr>
<td>Nesting frequency</td>
<td>3 times/season or more.</td>
</tr>
<tr>
<td>Nesting interval</td>
<td>12 days.</td>
</tr>
<tr>
<td>Remigration</td>
<td>2-3 years or more.</td>
</tr>
<tr>
<td>Average clutch size</td>
<td>112 eggs/nest (Playa Norte 2014: 105 eggs/nest n=103).</td>
</tr>
<tr>
<td>Size of tracks</td>
<td>100-130cm.</td>
</tr>
<tr>
<td>Track shape</td>
<td>Symmetrical.</td>
</tr>
<tr>
<td>Depth and width of nest</td>
<td>Approx. 60/35cm.</td>
</tr>
<tr>
<td>Nesting period on the Caribbean Coast</td>
<td>June to October: Barra del Colorado, Tortuguero, Parismina, Pacuare, Matina, 12 millas, Negra, Cahuita, Gandoca.</td>
</tr>
<tr>
<td>Nesting period on the Pacific Coast</td>
<td>September to March: Cabuyal, Ostional, Caletas, Camaronal, Matapalo, Nancite, Naranjo.</td>
</tr>
<tr>
<td>Pivotal incubation temperature</td>
<td>28.6 °C.</td>
</tr>
<tr>
<td>General characteristics</td>
<td>Four pairs of lateral scutes on the carapace. Maximum carapace length 120 cm. One pair of prefrontal scales and two pairs of postorbital scales. The average adult is around 100 cm in length and weighs from 100 to 225 kg. Its shell is greenish and black, scales do not overlap and the plastron is yellowish. It has a claw on the outside of each flipper.</td>
</tr>
<tr>
<td>Incubation period</td>
<td>48-70 days.</td>
</tr>
</tbody>
</table>

Hawksbill Turtle (Eretmochelys imbricata)

Relative to greens or leatherbacks far fewer data are available on the ecology and life cycle of the hawksbill turtle. The name is derived from their hawk-like beak, a dietary adaptation enabling them to consume silica rich sponges, their main food source (Meylan 1988). Hawksbill stomach content analysis found over 90% of the dried content was sponge - including species known to be highly toxic to fish and with a silica content similar to opal; a type of glass (Meylan, 1988). Due to their specialized diet hawksbills inhabit tropical coral reefs and once played a unique ecological role in maintaining the structure of the reef system and maintaining the stability of the food web (Spotila, 2004).

Until recently it was questioned whether this species was migratory, which the Cuban government used to argue a sovereign right over the harvest of the species in Cuban waters, despite it being afforded intentional protection (Mortimer et al., 2007). However, recent mitochondrial DNA (mtDNA) haplotype data have disputed this, confirming that harvesting at the national level is likely to impact on the species globally ( Bowen et al., 2007). What remains unknown, however, is why the species migrates from apparently suitable nesting sites close to its...
feeding grounds, to nest on its natal beach hundreds, possibly thousands of miles away (Spotila, 2004). See Table 1b for the characteristics of this species.

Table 1b. Characteristics of the Hawksbill turtle (Eretmochelys imbricata). (Adapted from Chacón et al., 2007)

<table>
<thead>
<tr>
<th>Scientific name: Eretmochelys imbricata</th>
<th>Common names: Tortuga carey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average length (CCL)</td>
<td>85.97 cm (n=148)</td>
</tr>
<tr>
<td>Nesting frequency</td>
<td>5 times/season.</td>
</tr>
<tr>
<td>Nesting interval</td>
<td>14-16 days.</td>
</tr>
<tr>
<td>Remigration</td>
<td>2-3 years.</td>
</tr>
<tr>
<td>Average clutch size</td>
<td>155 eggs/nest.</td>
</tr>
<tr>
<td>Size of tracks</td>
<td>70-85cm.</td>
</tr>
<tr>
<td>Track shape</td>
<td>Asymmetrical.</td>
</tr>
<tr>
<td>Depth and width of nest</td>
<td>Approx. 55/30cm.</td>
</tr>
<tr>
<td>Nesting period on the Caribbean Coast</td>
<td>May to November: Barra del Colorado, Tortuguero, Parismina, Pacuare, Matina, 12 millas, Negra, Cahuita, Gandoca and Uvita.</td>
</tr>
<tr>
<td>Nesting period on the Pacific Coast</td>
<td>May to January: Langosta, Manuel Antonio, Nancite, Jacó y Barú.</td>
</tr>
<tr>
<td>Pivotal temperature</td>
<td>29.32 °C.</td>
</tr>
<tr>
<td>General characteristics</td>
<td>Four pairs of lateral overlapping scutes on the carapace. Elongated head with two pairs of prefrontal scales and three postorbital scales. Upper jaw thrust forward. Adult weight can range from 25 to 90 kg; the average is between 45 and 70 kg. Its shell can grow to between 65 and 90 cm and colouration varies from yellow to black through to orange and also shades of red. The front flippers usually have two claws.</td>
</tr>
<tr>
<td>Incubation period</td>
<td>47-75 days.</td>
</tr>
</tbody>
</table>

**Anthropogenic threats**

Aside from natural threats such as predation and tidal inundation of nests, green and hawksbill turtles, like all species of marine turtle, are under threat from man in both the marine and terrestrial environment (Troëng & Rankin 2005, Mrosovsky et al., 2009). Pelagic long-line fisheries, entanglement in fishing gear and propeller strikes are common causes of marine turtle mortality (Troëng, 1998; James et al., 2005). Ingestion of marine debris, which affects feeding behavior, poses a significant threat to marine turtles (Bjorndal et al., 1994; Bugoni et al., 2001; Vélez–Rubio et al., 2013).

It has been estimated that green turtle numbers in the Caribbean exceeded tens of millions before the arrival of Europeans in the 15th century and that harvesting has reduced the population by 93-97% (Jackson et al., 2001). This decline has been mirrored throughout the tropics with the
species being exploited for its meat and eggs (Troëng & Rankin 2005). Hawksbill eggs are also consumed in large quantities but until recently the greatest threat to this species was from the trade in its much revered shell (tortoise-shell, raw scutes) and carey (worked shell)-used for ornamentation and jewelry (Márquez, 1990; Choi & Eckert, 2009).

All species of marine turtle are affected by domestic dog predation of nests (Choi & Eckert, 2009). Hatchlings that successfully emerge are vulnerable to disorientation caused by artificial light pollution, entanglement in marine debris and predation (Witherington & Martin, 2003; Bourgeois et al., 2009; Triessnig et al., 2012; Berry et al., 2013). While data are limited, currently a 1:1000 egg to adulthood ratio is estimated (Frazer, 1986).

**Current status and conservation efforts**

Due to the rapid decline in numbers, both greens and hawksbills are afforded international protection. All marine turtle species are listed under several international conventions, including Appendix I of the Convention on International Trade in Endangered Species (CITES). This prevents almost all of international trade in the species or their derivatives. They are also listed under Appendix I and II of the Convention on Migratory Species of Wild Animals (CMS) and the Inter-American Convention for the Protection and Conservation of Sea Turtles (IAC). Greens are listed as Endangered and decreasing and hawksbills as Critically Endangered and decreasing on the IUCN Red List of Threatened Species (Seminoff, 2004; Mortimer & Donnelly, 2008).

Ex-situ conservation efforts for marine turtles include relocating nests to hatcheries, head-starting programs and conservation medicine & rehabilitation and are beyond the scope of this report (see: Chacón et al., 2007; Phelan & Eckert, 2006). One initiative that has been introduced to protect marine turtles at sea have been Turtle Excluder Devices (TEDs) which act as a trap-door enabling turtles caught in gill nests to escape (Safina, 2007). In-situ protection includes patrolling beaches to prevent poaching, the relocation of nests laid too close to the tide line and undertaking tagging and monitoring programs to assess the population density of the species. These methods have been attributed to the increase of the nesting population in the Caribbean and are methods employed by marine turtle conservation projects in Costa Rica (Bjorndal et al., 1999; Dutton et al., 2005; González Prieto & Harrison, 2011).

The COTERC Marine Turtle Tagging and Monitoring Program is one of these projects and works on Playa Norte (see Study site). According to Costa Rican law N° 8586 (conservation of migratory species and wild animals) articles 1° and 3° (including endangered marine species and habitats as part of the distribution of migratory species), public access to Playa Norte beach is prohibited between 18.00 and 05.00 during the marine turtle nesting season. This legally corresponds to the period from 1st March until 31st October. In addition the Marine Turtle Monitoring and Tagging Program focuses on in-situ conservation, through the protection of nests, beach cleans to remove marine debris, working to reduce artificial lights on the beach and environmental education.
Methods

Study area

Data collection was carried out along a 3 1/8 mile (approximately 5km) beach transect on Playa Norte (Fig. 1), stretching from the river mouth of Laguna Tortuguero (Datum WGS84 552224.9E 1170322N) to Laguna Cuatro (Datum WGS84 550043.7E 1175989N). Playa Norte is part of the Barra del Colorado Wildlife Refuge, bordering Tortuguero National Park to the south. The area is managed by the Tortuguero Conservation Area (Área de Conservación Tortuguero, ACTo) and is regulated by Ministerio de Ambiente y Energía (MINAE) - the Costa Rican Ministry of Environment and Energy. In previous years the patrols started at the 0 mile marker, but this year, due to the activity observed outside the south limit of the transect in previous years, we started our night patrols and morning census 500 meters south of the 0 mile marker, all the activity recorded in this area was considered from this marker.

Along the beach transect mile markers where placed every 1/8 of a mile to facilitate the orientation and to allow spatial distribution analysis. These markers were replaced and painted in February, as well as every time it was necessary. The GPS coordinates of the markers were recorded with a Garmin GPSMAP 62S device for the spatial analysis.

A semi-illuminated path runs parallel to the beach. There are two hotels (Hotel Vista al Mar – not in functions – and Turtle Beach Lodge) and several private residencies along the beach transect. The public lights on the path and the private lights from hotels and houses can cause artificial light pollution in the vegetation along the beach, and sometimes directly on the beach.
itself, which poses a threat to the orientation of nesting turtles and emerging hatchlings (Witherington & Martin, 2003; Bourgeois et al., 2009; Berry et al., 2013).

Beaches and wetlands in Costa Rica are legally protected under Resolución ACTo-Dirección-04-2013, and as such the use of motorized vehicles is prohibited in the area anywhere within 200 meters inland of the high tide line. This would include the public path parallel to Playa Norte. Nonetheless, vehicles including motorbikes, four-wheel quads, and occasional trucks are observed.

For analysis purposes the beach is divided vertically into three sections: open, border and vegetation. These categories are defined according to the maximum amount of shade they receive in a day (Fig. 2).

Figure 2. Vertical beach zones. Open: >50% of direct sun light exposition, Border: ~50% of direct sun light exposition, Vegetation: <50% of direct sun light exposition.

Data collection

Night Patrol Protocol

Patrols were carried out every night from March 29th – October 29th. Every team covered shifts between 4, 5 and 6 hours. For safety reasons every team had a minimum of 3 people. Teams were scheduled in overlapping shifts in an effort to maximize our presence on the beach, while covering as much distance as possible (Fig 3). The starting and ending time of the patrols were changed regularly to avoid becoming predictable for the poachers and to adjust to the nesting patterns. In figures 3 and 4 you can see examples of the strategies used.

<table>
<thead>
<tr>
<th>Hour</th>
<th>20.00</th>
<th>21.00</th>
<th>22.00</th>
<th>23.00</th>
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<th>02.00</th>
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<tbody>
<tr>
<td>PM1</td>
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<td>PM2</td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>

Figure 3. Example of Night Patrol shifts with two teams.
In order to ensure the safety of our teams, minimize the impact on turtles and be as discrete as possible in the beach, Night Patrols have the following rules:

- Dark clothing must be worn.
- No alcohol before or during Night Patrol.
- No smoking during Night Patrol.
- Limit light usage and only use red light.
- Do not apply insect repellent before or during patrol.
- Stay behind or next to patrol leader (PL) at all times.
- If you see poachers tell the PL, never approach poachers.
- Walk on or below the most recent high tide line when possible.
- Keep quiet when walking the beach and when encountering a turtle.
- Never walk in front of the turtle or shine light near its head.
- Taking pictures or video it’s not allowed in night patrol.
- Patrol is cancelled or delayed if there is a lack of appropriate personnel or during extreme lightning storms when there is a risk of injury.

Night Patrols collected data on:

1. **Tracks and nests (when the turtle is absent):** For each encounter the species and location data (northern mile marker, vertical beach zone, G.P.S. co-ordinates and G.P.S. accuracy - hereafter referred to as Location Data) were recorded. The vertical beach zone and the G.P.S. coordinates of halfmoons were taken at the furthest point from the tide line that the turtle had reached. The encounter was recorded either as NST (nest) or HLF (halfmoon).

2. **Nesting sea turtles:** For all turtles encountered the following was recorded: species, encounter time, encounter activity (nesting stage/halfmoon) and location data. If encountered before oviposition, it was possible to count the eggs. The nest was triangulated if encountered before...
oviposition, or during oviposition, provided eggs were still visible. For all nesting turtles encountered, the flippers were checked for pre-existing tags and evidence of old tags (indicated by holes or notches in areas commonly used for tag placement). If no tags were found, the turtle was given new tags. Once collection of tag data/tagging occurred, morphological measurements were taken and an external health-check conducted. If a nesting sea turtle was encountered on her way back to sea, she was checked for the pre-existing tags if possible. If tags were present, tag data was recorded, and morphological data taken and health check performed, again, if possible. If the turtle did not have tags, administering new tags was not attempted, due to risk of injury to the turtle. A turtle facing the sea and located halfway between the sea and the vegetation zone was assumed to be returning to the sea. Turtles may have been stopped by the Patrol Leader to read tags in these circumstances. An overview of the different nesting stages and appropriate action to be taken by the team is provided in Table 2.

Table 2. Stages of the nesting activity and corresponding actions taken by patrol teams.

<table>
<thead>
<tr>
<th>Nesting stage</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Emerging</td>
<td>Wait</td>
</tr>
<tr>
<td>2) Selecting nesting site</td>
<td>Wait – Patrol leader checks on progress.</td>
</tr>
<tr>
<td>3) Cleaning</td>
<td>Wait – Patrol leader checks on progress.</td>
</tr>
<tr>
<td>4) Digging egg chamber</td>
<td>Wait – Patrol leader checks on progress.</td>
</tr>
<tr>
<td>5) Oviposition</td>
<td>Egg counting and nest triangulation</td>
</tr>
<tr>
<td>6) Covering egg chamber</td>
<td>Egg depth, tag data, minimum Curved Carapace Length (CCLmin) &amp; maximum Curved Carapace Width (CCWmax), and body check.</td>
</tr>
<tr>
<td>7) Disguising the nest</td>
<td>Tag data, minimum Curved Carapace Length (CCLmin) &amp; maximum Curved Carapace Width (CCWmax), and body check.</td>
</tr>
<tr>
<td>8) Returning to sea</td>
<td>Check for tags, and if present: tag data, minimum Curved Carapace Length (CCLmin), maximum Curved Carapace Width (CCWmax), and body check (at the patrol leader’s discretion).</td>
</tr>
</tbody>
</table>

A. Egg count and nest triangulation

Eggs were counted during oviposition by placing a hand below the cloaca and counting each egg as it passed over the hand into the egg chamber. While the turtle was digging the egg chamber the patrol leader created a shallow channel to the mouth of the egg chamber. This channel allowed the person counting eggs to position one hand underneath the cloaca, while reducing the risk of touching it. A medical latex glove was worn when counting eggs. The Nest ID (a piece of flagging tape containing the nest identification number; Fig. 5) was dropped into the nest at the beginning of oviposition, after which egg counting and triangulation of the nest began. The yolked eggs were counted using the counter, and the number of yolkless eggs was counted mentally. At the end of oviposition, when the turtle began covering the egg chamber with her rear flippers, the distance from the uppermost egg to the top of the egg chamber (egg depth) was measured (cm) with a flexible 3m measuring tape.

Egg counting and triangulation were conducted simultaneously. The end of a 50m tape measure was held directly over the egg chamber, taking care to avoid contact with the turtle. The
triangulation team tied the appropriately labelled (center, north and south) flagging tape on three sturdy pieces of vegetation with at least 45 degree angles from one another (Fig. 6), and recorded the distances from the nest to these pieces of vegetation using the 50m measuring tape.

![Triangulation Tapes](image)

**Figure 5.** Triangulation tapes (Three on top: North, Center and South) and Nest ID (bottom).

![Nest Triangulation Diagram](image)

**Figure 6.** Nest triangulation

B. Tag information

Tagging enables the identification of individual turtles, which in turn allows us to build up an historical record of that individual. This includes morphometric data, nesting events, and health status. Greens and hawksbills are tagged in the front flippers (Fig. 7a).

On completion of oviposition the patrol leader checked the rear flippers for existing tags and evidence of previous tags. The right rear flipper was always checked and recorded before the left. If tags were present, the numbers were recorded (numbers repeated twice by the person checking the tag and the data recorder). Old tag evidence was recorded as either an Old Tag
Hole (OTH) (Fig. 7b) or Old Tag Notch (OTN) (Fig. 7c). Illegible tags, tags causing damage (e.g. ingrown) or tags that were likely cause damage or fall out in the near future (e.g. tag placed too far in with a risk of becoming ingrown, or tag placed too far out with the risk of catching on something and ripping out) were removed and replaced. If no tags were present, the Patrol Leader administered new ones.

A correctly placed tag is positioned so that one third (or two numbers) of the tag is off of the flipper and two thirds (or four digits) are over the flipper. This prevents friction and allows space for possible swelling. The lower tag number is always placed on the right flipper and the higher on the left. Removing tags only takes place after the tag data from the other flipper are recorded. Two tags are never placed in one flipper; an old tag would always be removed before a new tag is placed in the same flipper. This avoids a turtle going back to the sea without tags, what would mean to lose all the information for that individual.

![Figure 7. a) Tag position for hard shell turtles, b) Old tag holes (OTH), c) Old Tag Notch (OTN).](image)

C. Biometric measurements

Once the turtle had been tagged, or existing tag data recorded, the length and width of the carapace was measured with a 3m flexible measuring tape. The Curved Carapace Width maximum (CCWmax) and Curved Carapace Length minimum (CCLmin) were measured (Fig. 8). The CCL starts at the point where the skin meets the carapace at the neck and ends along the line between the two marginal scutes on the edge of the carapace. It is important that the end point of CCLmin is always measured along the line between the two marginal scales, even if the carapace is shorter at this point. CCWmax has a less obvious start and end point, but is taken at the widest point of the carapace. The CCW is measured from the edge of the carapace on one side to the edge of the carapace on the other side at its widest point, which is usually around the middle. For quality control purposes each measurement was taken at least three times, more if the measurements varied by more than 1cm. If anything affected the measurements (e.g. barnacles), it was recorded in the body check.
D. Body check

A general health assessment was performed after the measurements were recorded. Injuries (scars, holes, notches, missing parts of flippers, bite marks), barnacles, tumors, parasites and any other abnormalities were recorded. Evidence of previous tags was not recorded during the body check, as this was recorded when checking for tags.

The body check was carried out following a standardized protocol in which each predefined body zone is given a number from one to eight (Fig. 9). A diagram of the zones was available in the front page of every field book, as a guide. The person performing the body check started with zone two (right front flipper) and moved around the body in a clockwise direction. Since zone one (the neck and head) is the most sensitive part of the turtle, and checking it bears the greatest risk of disturbing the turtle, it was done last and with great care. To check zone one, the red light was shielded with one hand and moved slowly from the top of the carapace over to the neck and head while always avoiding light anywhere near the turtle’s eyes.

Barnacles can bias measurements and are an indication of ill health and therefore were recorded when encountered. Size (small, medium and large with examples traced in the data field books for reference), distribution pattern (clustered or scattered) and abundance (1-5 = few, 6-15 = moderate, 16+ = many) were all noted.
During the body check the light was orientated away from the turtle's head and turned off at any break in the assessment in order to minimize potential disturbance. All abnormalities were recorded per zone, with any estimated measurements and name of the surveyor noted. A circle was drawn around the zone number in order to prevent later confusion between zone numbers and measurements. If no abnormalities were found “Body Check: All Good” was recorded to confirm the body check has been completed.

E. After working the turtle

Once the data collection was completed and checked by at least one other team member, the team waited until the turtle returned to the sea and recorded the GPS point of the nest. The tracks and nest were disguised. When disguising nests, the objective was to flatten the sand as much as possible in order to allow the sand to dry quicker and make it harder for potential poachers to find the egg chamber. In order to prevent affecting incubation, great care was taken not to cover the egg chamber with anything. Seaweed may have been placed around the nest area in order to make it blend into the surroundings better.

Human Impact Survey

Public access to Playa Norte is prohibited between 18.00h and 05.00h from March 1st to October 31st. However, due to the low level of law enforcement on Playa Norte, illegal human activity is frequently observed. In collaboration with MINAE, a standardized Human Impact Survey was carried out as part of the nightly patrols throughout the season. Human Impact was divided into six categories: white light (W), cellphones (C), red light (R), fire (F), local (L), tourist (T) and dogs (D). Temporal and spatial distribution was also recorded for each impact category. The results are weekly reported to MINAE.

Light Survey

In addition to the Human Impact Survey, a monthly Light Survey was conducted on the night of the new moon. This survey was always conducted by first patrol, and recorded the permanent artificial lights that were illuminated along the beach transect at the time of the survey. Lights were only recycled if it was possible to see the bulb, and were counted when the surveyors walked past to prevent double counting. Team members individually noted the number of bulbs they observed in each mile marker and the average of these counts were taken and rounded to the nearest whole number. Distinctions were made between white and yellow lights and it was also recycled if they were public lights or private.

Morning Census Protocol

Morning Census was carried out daily from March 25th through September 17th, starting at 5:30 and surveyed the entire transect.

Collected data:

1. Nest and track information: Morning Census recorded any additional tracks and nests on the beach that had not been encountered by the previous night’s patrol teams. To prevent
double counting, a copy of the activity data from the previous night was recorded in the Morning Census book for reference during the survey.

2. **Check of all triangulated nests**: All triangulated nests were checked daily from the day after they were laid to the day of their excavation. The accuracy of the nest’s triangulation was checked by morning census the morning immediately after the nest was triangulated. In the event that the lines of the triangle were over 50cm, or the lines did not make a triangle, the night patrol team returned to the nest to correct the triangulation. The status of the nest itself was assessed and any signs of abnormality recorded. Condition classifications were as follows:

   - **Natural (NAT)**: nest is in a natural state with no disturbance.
   - **Wet (WET)**: nest is below the most recent high tide line.
   - **Flooded (FLO)**: nest is completely covered by water from the tide.
   - **Poached (POA)**.
   - **Predated (PRE)**.
   - **Partial Predation (PART/PRE)**.
   - **Predation Attempt (PRE/ATT)**.
   - **Unknown (UNK)**: status undetermined or it was not possible to access the nest.
   - **Eroded (ERO)**: a cliff has been created by the tide and the nest is now below this cliff, eggs may also be visible.
   - **Hatching evidence (HAT)**: hatchling(s) or hatchling tracks from nest are present.
   - **Depression (DEP)**: there is a depression on the surface of the nest.*
   - **No Depression (No DEP)**: there is no depression on the surface of the nest.*

   * Recorded after the depression sticks have been erected (see below).

Green and hawksbill incubation periods range from 48-70 and 47-75 days respectively (Chacón et al., 2007). On Playa Norte the 2016 mean for greens was 61.3 days (± 6.15) and for hawksbills was 77.6 days (± 30.88) (McCargar & Humphreys, 2016). On day 50 depression sticks erected to ease checking for signs of hatching (depressions or hatchling tracks) (Fig. 10). Indications of hatching include a physical depression in the sand around the nest area caused by hatchlings digging their way to the surface inside the nest, very soft sand in the top 10cm of the nest area or a small cave-like hole where hatchlings have emerged. Hatchling tracks leading away from the nest may also be present. Possible depressions are confirmed with the help of the eraser end of a pencil that is gently pushed into the depression area. If the sand underneath gives way very easily it is considered a depression.
Assessments of the nest status each day allowed for detailed conclusions of the nests’ fate, as well as temporal analyses of any disturbance. Daily assessments of the intactness of triangulation flagging tapes were essential in order to avoid data loss, as termites, ants or people regularly destroyed tapes.

3. **Nest excavations**: when the incubation period was complete (see excavation protocol), nests were excavated by the Morning Census team or addition teams during busy periods.

**Excavation Protocol**

Nest excavations are conducted to determine the nest success of triangulated nests. Nest success is divided into hatching and emerging success. Hatching success is the total number of hatchlings that exited the egg. The total number of hatchlings that emerged from the nest is referred to as the emerging success. A number of abiotic and biotic variables can cause partial or complete nest failure, including: temperature, moisture, root invasion, flooding, erosion, predation and poaching (Kamel & Mrosovsky, 2004).

Nests were checked daily and were excavated under the following circumstances:

1. If hatchling tracks present – excavate two days later.
2. If five consecutive days of depression – excavate on the following (sixth) day.
3. If no signs of hatching were present by 75 days – excavate on 75th day.

The first stage of excavations was to locate the egg chamber by re-triangulating the nest. Sand was then carefully removed using a cupped hand until the first signs of the nest appeared (e.g. eggs, empty eggshells or hatchlings). The egg depth was taken from the top of the nest using the bottom flat part of a stick lying over the entrance (Fig. 11). The nest contents were removed and sorted into different categories (Table 3 and Fig 12). Finally, nest depth was measured from the bottom of the nest to the surface of the beach again using a horizontal stick over the egg chamber for reference.
Table 3. Nest contents

<table>
<thead>
<tr>
<th>Nest content</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipped eggs (PE)</td>
<td>Egg is intact apart from a small triangular hole caused by the hatchling’s egg tooth. The hatchling is dead inside the egg and the head is near the hole.</td>
</tr>
<tr>
<td><strong>Hatched eggs:</strong></td>
<td></td>
</tr>
<tr>
<td>Empty egg shells (EES)</td>
<td>Only shells &gt;50% intact were considered. Pieces of shell &lt;50% could not be counted, as it cannot be determined from how many different eggs they originated.</td>
</tr>
<tr>
<td>Dead Hatchlings (DH)</td>
<td>Hatchlings that exited the egg, but died inside the nest.</td>
</tr>
<tr>
<td>Live Hatchlings (LH)</td>
<td>Hatchlings that exited the egg, but have not emerged from the nest (yet).</td>
</tr>
<tr>
<td><strong>Unhatched eggs:</strong></td>
<td></td>
</tr>
<tr>
<td>Yolkless eggs (Y)</td>
<td>Non-fertilized eggs that range from 1cm diameter to a diameter similar to yolked eggs. Leatherback nests usually contain ~10-40 yolkless eggs.</td>
</tr>
<tr>
<td>No Embryo (NE)</td>
<td>Yolk present with no embryo.</td>
</tr>
<tr>
<td>Embryo Stage 1-4 (E1-4)</td>
<td>Eggs that did not develop or died during development.</td>
</tr>
<tr>
<td>Stage 1 (E1): embryo occupies ≤ 25% of the egg; can be as small as a spot of blood within the yolk.</td>
<td></td>
</tr>
<tr>
<td>Stage 2 (E2): embryo occupies 26-50% of the egg.</td>
<td></td>
</tr>
<tr>
<td>Stage 3 (E3): embryo occupies 51-75% of the egg.</td>
<td></td>
</tr>
<tr>
<td>Stage 4 (E4): embryo occupies &gt; 75% of the egg (Fig. 12).</td>
<td></td>
</tr>
<tr>
<td>Predated (P)</td>
<td>Predated eggs are categorized as follows:</td>
</tr>
<tr>
<td></td>
<td>• Dogs (or other mammals).</td>
</tr>
<tr>
<td></td>
<td>• Microorganisms (fungi or bacteria) – established by smell and color.</td>
</tr>
<tr>
<td></td>
<td>• Holes caused by crabs.</td>
</tr>
<tr>
<td></td>
<td>• Other/unknown.</td>
</tr>
<tr>
<td></td>
<td>The presence/absence of ants and maggots in the nest was also recorded.</td>
</tr>
<tr>
<td>Deformed Embryos (DE)</td>
<td>Common deformities include abnormal numbers of scutes, no-eyes (eyes overgrown with skin), albino, twins, and injuries or tumor-like growth on head.</td>
</tr>
</tbody>
</table>
Excavations were stopped and postponed for seven days if more than five live hatchlings were present in the nest or if the eggs appeared to still be developing (white and firm). If fewer than five live hatchlings were present in the nest, the condition of the hatchlings was assessed using the completeness of the plastron and the level of activity as indicators. If the plastron was still open and/or the hatchling was lethargic, they were reburied next to the original nest at the same depth at which they were found. If the plastron was closed and they were very active, the hatchlings were allowed to make their way to sea naturally. Assistance was only given to the hatchlings if the air or sand temperature was dangerously hot, at which point they were given shade en route to the sea or moved to an area of wet sand. Hatchlings were never put in the sea. If able to make their own way into the water, it can be assumed that the hatchlings are active enough to swim and keep their heads above water. Hatchlings always walk into the surf without assistance and from a reasonable distance, so they can prepare their muscles and lungs for swimming.
Hatching Success and Emerging Success are calculated for each excavated nest using the following formulas:

\[
\text{Hatching success} = \left( \frac{\text{Empty Shells}}{\text{Empty Shells} + \text{No Embryo} + \text{Stage 1} + \text{Stage 2} + \text{Stage 3} + \text{Stage 4} + \text{Pipped eggs} + \text{Predated eggs} + \text{Deformed embryos}} \right) \times 100
\]

\[
\text{Emergence success} = \left( \frac{\text{Empty Shells} - (\text{Live hatchlings} + \text{Dead Hatchlings})}{\text{Empty shells} + \text{No Embryo} + \text{Stage 1} + \text{Stage 2} + \text{Stage 3} + \text{Stage 4} + \text{Pipped eggs} + \text{Predated eggs} + \text{Deformed embryos}} \right) \times 100
\]

Un-triangulated nests were not always excavated, as exact locations of un-triangulated nests were unknown. However, if hatching tracks were observed coming from an un-triangulated nest, it was excavated two days later. These excavations followed the same protocols as was used for excavated nests, excluding re-triangulation. Eggshell samples of 1cm² were taken from both triangulated and un-triangulated nests, as were embryonic tissue when available (from embryos that died before hatching). These will contribute to a study on the population genetics of turtles nesting on Playa Norte, using non-invasive sampling methods.

**Relocation Protocol**

The nest relocations are carried out when there is a 100% percent probability the nest is going to be lost due to flooding of the egg chamber by the tide. If the water is flooding the egg chamber in the oviposition stage, the eggs are removed and translocated to an artificial egg chamber, farther away from the tide line. An egg chamber is dug with the same dimensions of the original one and in the same vertical zone. The general rule for leatherback nests is one meter depth with an egg chamber the size of a basketball ball. All the eggs are handled with latex gloves and are re-counted when placed in the nest. Extreme care is taken not to turn the eggs and to place them in the same position they were laid originally. All the excavations have to be done while or immediately after the oviposition. It’s recommended that the relocations take place in the five hours after the eggs are laid, since it has been found that the movement of the eggs after six hours signifies a greater risk in the embryonic mortality (Parmenter, 1980; Chacón et al., 2007).

**Trainings**

Prior to working on the beach at night all volunteers received standardized training in our protocols. Training 1 is a Morning Census PowerPoint and Training 2 is a PowerPoint on Night Patrol followed by a simulation exercise of working a turtle on the beach. All visitors staying longer than two weeks were then required to sit an exam in which they needed to score 80%. Potential patrol leaders were required to achieve 95% in this exam, although a score of 90% would lead to an oral re-sit.

Passing with this grade lead to practice patrol leading with a qualified patrol leader (a staff member) until they were deemed sufficiently experienced to receive tagging training – using
cardboard to simulate flippers. Where possible practice patrol leaders were supervised the first time they tagged a turtle and were then able to take out their own teams at night.

Once excavations begin occurring, all interns and volunteers are also required to undergo additional training for excavations: a PowerPoint and a practical demonstration by a staff member on how to conduct excavations. During weekly turtle meetings, additional training in Emergency Action Planning (EAP) was given by discussing various scenarios that require practical and critical thinking. At least five scenarios were discussed per meeting. Further safety training in lightning protocols was also given to all volunteers and interns participating in turtle related activities. See Table 4 for more details on each training.

<table>
<thead>
<tr>
<th>Table 4. Trainings</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Morning Census presentation (Training 1) – Classroom.</strong></td>
</tr>
<tr>
<td>Training presentation on the biology of the species and the threats and the conservation actions in place for marine turtles, the methodology and protocols for Morning Census.</td>
</tr>
<tr>
<td><strong>Night Patrol training (Training 2) – Classroom and Beach.</strong></td>
</tr>
<tr>
<td>Training presentation on our Night Patrol protocols, and a simulation of working a turtle on the beach. The simulation is undertaken in the order of events from encountering the tracks, triangulating the nest, taking the biometric data, through to correctly completing the data book and protocols for once the turtle has returned to sea. Locating the nest by reverse triangulation.</td>
</tr>
<tr>
<td><strong>Excavation presentation – Classroom and practical demonstration – Beach.</strong></td>
</tr>
<tr>
<td>Theoretical and practical training in conducting nest excavations and recoding the data.</td>
</tr>
<tr>
<td><strong>Tagging training – Classroom (Potential patrol leaders only).</strong></td>
</tr>
<tr>
<td>Practical simulation training in flipper tagging using cardboard “flippers”.</td>
</tr>
<tr>
<td><strong>Emergency Action Planning – Classroom.</strong></td>
</tr>
<tr>
<td>Discussion session covering emergency scenarios and tricky situations that have happened in the past and ways of dealing with them.</td>
</tr>
<tr>
<td><strong>Lightning Safety Training – Classroom.</strong></td>
</tr>
<tr>
<td>Practical session on how to assess the dangers of being on the beach in a lightning storm, how to monitor the storm, when to leave the beach and where/where not to shelter. Includes scenarios for discussion at the end.</td>
</tr>
</tbody>
</table>
Results

Survey Effort

Night Patrol

Night patrols started on March 29th and finished on October 29th. When there was only one team on the beach the patrol lasted six hours: from 21:00 to 03:00, when we had enough personnel to have two teams each patrol lasted for five hours, the first one from 20:00 to 01:00, and the second one from 23:00 to 04:00.

Due to the lack of personnel we only had one patrol during peak season, after August 16th we were only able to have two patrols on the beach the 10th of August, and from that on we only had one team on the beach. In October, due to lack of personnel and/or sickness of the trained personnel, we were not possible to cover the nesting activity on a daily basis, we had one team on the beach in just 14 occasions.

Mean hours spent patrolling per night each week varied from 1.63 (1 hour, 38 minutes) to 12.14 (12 hours, 10 minutes) (Fig. 14). Beach presence was kept at maximum, according to the number of personnel available (Fig. 14). The total number of hours spent on Night Patrol was 1,572 hours and 20 minutes, and the mean per night was 7 hours and 11 minutes (Fig. 14). For analysis, all dates 29 and over in a month are included in the week 4 of the same month.

Figure 14. Survey effort and beach presence – Bars indicate the weekly average hours that the beach was covered per night in Playa Norte from March 29th to October 29th. The line indicates the weekly average of patrol teams per night from March 29th to October 29th 2017.
**Morning Census**

Morning census was carried out every morning from March 25th until December 17th. The total time spent on Morning Census was 850 hours, with an average of 3 hours and 10 minutes per day (Fig 15).

![Figure 15. Morning Census effort](image)

The bars indicate the average of hours spent per morning census in Playa Norte from March 25th to December 17th 2017.

**Nesting activity**

A total of 333 green nests and 832 halfmoons, as well as 71 hawksbill nests and 93 halfmoons were recorded between March 25th and December 9th (Table 5). An additional two green nests and three halfmoons were recorded north of mile 3 1/8 (Table 6). It is worth mentioning this year we had a loggerhead nesting event (*Caretta caretta*) in mile 1 1/8 on July 30th; it was possible to tag the turtle, take measurements and mark the nest.

Our patrol teams encountered the turtle in the 39% (130 out of 333) of the green nesting events, and in the 52.1% (37 out of 71) of the hawksbill nesting events, making a total of 41.48% (168 out of 405) of the nesting events. It was possible to triangulate the 30% (122 out of 405) of the nests, 28% (93 out of 333) of the green nests, and 39.4% (28 out of 71) of the hawksbill nests.

A total of 925 halfmoons were recorded between February 14th and November 7th, 832 of them were from greens and 93 were from hawksbills. Out of these, on 135 times (14.6%) our patrol teams encountered the turtle present, 127 times (15.3%) of greens, and 8 times (8.6%) of hawksbills.
Table 5. Nesting Activity – Number of encountered nests by specie and in total from March 25th to December 9th 2017.

<table>
<thead>
<tr>
<th>Species</th>
<th>Total nests</th>
<th>Nests with turtle present</th>
<th>Nests with turtle absent</th>
<th>Triangulated nests</th>
<th>Halfmoons</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Chelonia mydas</em></td>
<td>333</td>
<td>130 (39%)</td>
<td>203 (61%)</td>
<td>93 (28%)</td>
<td>832</td>
</tr>
<tr>
<td><em>Eretmochelys imbricata</em></td>
<td>71</td>
<td>37 (52.1%)</td>
<td>34 (47.9%)</td>
<td>28 (39.44%)</td>
<td>93</td>
</tr>
<tr>
<td><em>Caretta caretta</em></td>
<td>1</td>
<td>1 (100%)</td>
<td>0</td>
<td>1 (100%)</td>
<td>0</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>405</td>
<td>168 (41.34%)</td>
<td>237 (58.66%)</td>
<td>122 (30%)</td>
<td>925</td>
</tr>
</tbody>
</table>

Table 6. Nesting Activity out of transect – Number of encountered nests by species and in total north of mile 3 1/8 from March 25th to December 9th 2017

<table>
<thead>
<tr>
<th>Species</th>
<th>Total nests</th>
<th>Nests with turtle present</th>
<th>Nests with turtle absent</th>
<th>Triangulated nests</th>
<th>Halfmoons</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Chelonia mydas</em></td>
<td>2</td>
<td>0 (0%)</td>
<td>2 (100%)</td>
<td>0</td>
<td>3</td>
</tr>
</tbody>
</table>

A total of 130 green turtles were encountered at some point of the nesting process. This encounters corresponded to 105 different individuals: 58 were RECs, 4 REMs and 25 RENs (Table 7). In the case of hawksbills, out of the 37 encounters 20 were RECs, 8 REMs and 8 RENs (Table 7). The encounter with the loggerhead was a REC.

Table 7. Tag Data

<table>
<thead>
<tr>
<th>Species</th>
<th>REC</th>
<th>REM</th>
<th>REN</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Chelonia mydas</em></td>
<td>58</td>
<td>47</td>
<td>25</td>
</tr>
<tr>
<td><em>Eretmochelys imbricata</em></td>
<td>20</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td><em>Caretta caretta</em></td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>79</td>
<td>55</td>
<td>33</td>
</tr>
</tbody>
</table>

Nesting activity for green and hawksbill turtles was concentrated in week 4 of August, a total of 54 nests were recorded, followed by week 4 of July where 37 nesting events were recorded, and the third most active week was the first of September with 36 nests recorded (Fig. 16). For halfmoons, the most active week was also week 4 of August with 134 events recorded, followed by week 4 of September with 98 records, and the third most active week of the season was the second of August with 93 halfmoons (Fig. 16). For analysis, all dates 29 and over in a month are included in the week 4 of the same month.
For greens, the most active week was the week 4 of August with 51 nests, followed by week 4 of July and week 4 of September, both with 32 records (Fig. 17). For the halfmoons, the most active week was week 4 of August with 132 records, followed by week 4 of September with 94, and the third most active week for green turtles was week 2 of August with 92 halfmoons (Fig. 17).

In the case of hawksbills, the nesting activity there is not such a significant trend as it is with the greens. As it can be observed in figure 18, the most active weeks for nests was week 4 of May with six, the weeks that followed were week 1 of July, week 3 of June, week 4 of July, week 3 of August, and week 1 of September, all of them with five nests each. For the halfmoons the most
active week was week 4 of May with 12 records, then week 2 and 4 of July with 10 records (Fig. 18).

![Temporal distribution of nesting activity for hawksbill turtles (Eretmochelys imbricata) in Playa Norte from March 25th to November 7th 2017.](image)

**Figure 18.** Temporal distribution of nesting activity for hawksbill turtles (*Eretmochelys imbricata*) in Playa Norte from March 25th to November 7th 2017.

In figure 19 a comparison of nesting activity and personnel availability can be seen, with the purpose to demonstrate the inverse correlation between both factors, this affects our ability to find and work as many turtles as possible in the peak of the season.

![Personnel availability against nesting activity. Temporal distribution of the nesting activity (red line) and the mean of team numbers per week (green bars) in Playa Norte from March 25th to November 7th 2017.](image)

**Figure 19.** Personnel availability against nesting activity. Temporal distribution of the nesting activity (red line) and the mean of team numbers per week (green bars) in Playa Norte from March 25th to November 7th 2017.

From March 25th to October 29th the hour most likely to encounter a nesting green turtle was between the 00.00h and the 00.59h (n=51), followed by the interval between 23.00h and 23.59h (n=50) (Fig. 20). The hour most likely to encounter a nesting hawksbill turtle was also between 00.00h and 00.59h, followed by the intervals between 21.00h – 21.59h and 02.00h – 02.59h (Fig.
The earliest a turtle was found was a green encountered at 20.05h, and the latest was a hawksbill found by morning census at 10.55h.

*Figure 20. Encounter times* – Bars represent the total number of green turtles (*Chelonia mydas*) and hawksbill turtles (*Eretmochelys imbricata*) encountered within a given hour from March 25th and October 29th. Each hour represents the minutes 00-59 within the given hour.

In terms of spatial distribution, both species showed a slight preference to the first half of the beach, especially in the case of halfmoons. The most popular mile for nests was 2/8 (n=38), followed by mile 2 1/8 (n=28). In the case of halfmoons, the most popular miles were 2/8 (n=104) and 3/8 (n=100) (Fig. 21).

*Figure 21. Spatial distribution of nests and halfmoons of green and hawksbill turtles* – Bar represent the nesting activity of both species along Playa Norte transect from March 25th to December 9th 2017.
Biometrics

The curved carapace length (CCLmin) and the curved carapace width (CCWmax), were successfully taken on 124 of 131 (94.68%) times it was possible to take the tag information for greens, for hawksbill the measurements were taken in 32 of the 34 (94.12%) times the tag information was recorded, for the loggerhead it was possible to take the measurements the only time the tag information was recovered. The mean CCLmin for greens was 105.73cm and the mean CCWmax was 95.57cm. For hawksbills, the mean CCLmin was 87.55, and the CCWmax was 78.85. A resume of the biometrics for the three species can be seen in table 8.

<table>
<thead>
<tr>
<th>Species</th>
<th>CCLmin (cm)</th>
<th>CCWmax (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ± SD</td>
<td>Range</td>
</tr>
<tr>
<td>Chelonia mydas</td>
<td>105.73 ± 5.67</td>
<td>92.1 – 121.9</td>
</tr>
<tr>
<td>Eretmochelys imbricata</td>
<td>87.55 ± 3.78</td>
<td>81.7 – 94.3</td>
</tr>
<tr>
<td>Caretta caretta</td>
<td>99.4</td>
<td>-</td>
</tr>
</tbody>
</table>

Body check

The body check for 122 green and 28 hawksbill turtles was successfully recorded. 40 of the 122 green individuals did not present any abnormality to report, the abnormalities and their distribution found in both species can be seen in tables 9 and 10. The most reported abnormality was the presence of barnacles in different parts of the body. No fibropapilloma was detected in any of the nesting females, though a juvenile turtle washed up dead on the beach and presented a big quantity of tumors.

For hawksbills, all the individuals presented barnacles in some part of their bodies, and there was no record of any abnormality in the head zone (number 1). It is worth mentioning one of the individuals presented a hole in the carapace that seemed to be done by a harpoon (Table 10).
**Table 10.** Body check hawksbill turtles (*Eretmochelys imbricata*) 2017.

<table>
<thead>
<tr>
<th>Zone</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barnacles</td>
<td>1 (3.57%)</td>
<td>23 (82.14%)</td>
<td>3 (10.71%)</td>
<td>21 (75%)</td>
<td>2 (7.14%)</td>
<td>18 (64.29%)</td>
<td>3 (10.71%)</td>
<td></td>
</tr>
<tr>
<td>Notches</td>
<td>1 (3.57%)</td>
<td>1 (3.57%)</td>
<td>3 (10.71%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cuts</td>
<td>1 (3.57%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scars</td>
<td>1 (3.57%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Holes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1 (3.57%)</td>
<td></td>
</tr>
</tbody>
</table>

The loggerhead turtle only presented barnacles in the carapace.

**Nest success**

**Nest Fate**

93 green turtle nests were triangulated on night patrol. One of them was lost when all three triangulation tapes were removed by unknown persons. Another nest presented the same situation, but thanks to a re-triangulation effort and the presence of hatchling tracks it was possible to be found. This season we didn’t have any nests eroded, flooded or destroyed by another turtle. 23 partially or completely poached nests were recorded, as well as 17 nests partially or completely predated (Table 11).

28 hawksbill nests were triangulated. In the same way as the greens, there were not loses due to erosion, flooding or destruction by another turtle. Five partially or completely poached nests were recorded, and nine partially or completely predated (Table 11).

The loggerhead nest was recorded as wet at the beginning of the incubations period, but this didn’t represented a significant disturbance for the embryos development.

**Table 11.** Nest fate of triangulated nests 2017.

<table>
<thead>
<tr>
<th>Fate</th>
<th>Green turtle (<em>Chelonia mydas</em>)</th>
<th>Hawksbill Turtle (<em>Eretmochelys imbricata</em>)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Percentage %</td>
</tr>
<tr>
<td>Not found</td>
<td>5</td>
<td>5.37%</td>
</tr>
<tr>
<td>Poached (Completely or partially)</td>
<td>23</td>
<td>24.73%</td>
</tr>
<tr>
<td>Predated (Completely or partially)</td>
<td>17</td>
<td>18.28%</td>
</tr>
<tr>
<td>Post emergence</td>
<td>1</td>
<td>1.07%</td>
</tr>
<tr>
<td>Found</td>
<td>48</td>
<td>51.61%</td>
</tr>
</tbody>
</table>
Predation

The 52.1% (63 out of 121) of the triangulated nests from all the species suffer some type of disturbance by predation. 36 (29.8%) attempts were recorded, 11 partial predations (9.1%) and 16 complete predations (13.2%). In the specific case of the green turtles, 50 nests were disturbed (53.8%): 33 attempts (35.5%), 7 partial predations (7.5%), and 10 complete predations (10.7%). For the hawksbills 13 nests were affected (46.42%): 3 attempts (10.7%), 4 partial predations (14.3%), and 6 complete predations (21.4%). This activity was mainly concentrated in the middle of the beach transect, the miles with the highest numbers of disturbances were 1 3/8 (n=7), 5/8 (n=6) y 1 4/8 (n=5). The highest number of total predations were recorded in miles 1 3/8, 5/8, and 1 4/8 with two events each (Fig.22).

![Figure 22. Predation pressure – Show number of triangulated green and hawksbill nests that experienced some form of predation pressure between miles 0 and 3 1/8 in Playa Norte from March 25th to December 9th 2017.]

Excavations

To calculate the hatching and emerging success some criteria is taken into account: nest ID found, no poaching (full or partial) activity recorded, no predation (full or partial) activity recorded, and a difference between eggs counted in triangulation and excavation of 10 or less (Table 12). It was possible to calculate the hatching and emergence success for 32 green nests, eight hawksbill nests and the loggerhead nest. Hatchling tracks were recorded in 15 green nests and in four hawksbill nests, only nests that had hatchling tracks recorded as coming from them were used in the calculation of incubation periods to ensure that they are as accurate as possible. Mean incubation period for greens was 55.3 days and 61.1 days for hawksbills (Table 13).
Table 12. Nest success (%)

<table>
<thead>
<tr>
<th>Species</th>
<th>Hatching success</th>
<th>Emergence success</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ± SD</td>
<td>Range</td>
</tr>
<tr>
<td>Chelonia mydas (n=15)</td>
<td>76.86% ± 29.24</td>
<td>2.25% - 98.89%</td>
</tr>
<tr>
<td>Eretmochelys imbricata (n=7)</td>
<td>76.5% ± 25.17</td>
<td>28.78% - 98.08%</td>
</tr>
<tr>
<td>Caretta caretta (n=1)</td>
<td>92.14%</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 13. Incubation period (days)

<table>
<thead>
<tr>
<th>Species</th>
<th>Mean ± SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chelonia mydas (n=15)</td>
<td>56.27 ± 3.97</td>
<td>50 - 63</td>
</tr>
<tr>
<td>Eretmochelys imbricata (n=9)</td>
<td>61.1 ± 11.62</td>
<td>53 - 62</td>
</tr>
</tbody>
</table>

Nest protection

This season we continued with the implementation of the nest protection project, placing protection barriers to the hawksbill nests at 10 cm depth and the green nests at 20 cm depth. At the beginning of the season the barriers were placed in all the nests, focusing in protecting the hawksbill nests as soon as possible, but in the middle of the season, due to the lack of available personnel, the barrier placing was suspended and where placed at the end of the incubation period, one week before, around day 50 of incubation.

76 protection barriers were placed in nests of three species. Four of the nests, two greens and two hawksbills were poached after the barriers were buried. In the case of greens, 27 (54%) of these nests suffered some kind of predation pressure, four (8%) were partially predated, and two (4%) were completely predated. In the case of hawksbills three (13%) predation attempts were recorded, five (20%) partial predations, and two (8%) complete predations. The loggerhead nest didn’t recorded any kind of predation or poaching attempt (Table 14).

Table 14. Nest protection.
Turtle Mortality and Poaching

This season a total of three dead turtles were recorded, all greens. Two of them were encountered in the path that goes along the beach in miles 7/8 and 1 2/8 on July 14th and July 24th respectively, both were found without flippers and plastron, so we were unable to determine if the turtles had been tagged. Another juvenile turtle was found washed up dead on the beach, in mile 3 on November 3rd, apparently is dead was caused by the great amount of tumors that she presented, causing a severe fibropapillomatosis (Table 15).

There were found 25 tracks of lifted turtles, 21 greens and four hawksbills. The spatial distributions of the lifting, flipped and dead events can be observed in figure 23, a trend of these events towards the first part of the beach transect can also be observed.

Table 15. Evidence of turtle mortality and poaching.

<table>
<thead>
<tr>
<th>Species</th>
<th>Deceased</th>
<th>Lifted tracks</th>
<th>Flipped</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Chelonia mydas</em></td>
<td>3</td>
<td>21</td>
<td>2</td>
</tr>
<tr>
<td><em>Eretmochelys imbricata</em></td>
<td>0</td>
<td>4</td>
<td>0</td>
</tr>
</tbody>
</table>

Figure 23. Distribution of Turtle Mortality and Poaching – Shows the spatial distribution of the turtles, greens and hawksbills, that suffered mortality or poaching evidence between miles 0 and 3 1/8 in Playa Norte from March 25th to December 9th 2017.
Genetic Samples

A total of 1449 non-invasive genetic samples were taken from 72 triangulated nests (60 green, 11 hawksbill and 1 loggerhead), and from 57 untriangulated nests (52 greens and 5 hawksbills). Excavations of untriangulated nests were performed after the hatchling tracks were recorded. Table 16 shows the total number of samples taken this season, which will be analyzed at a later time.

Table 16. Genetic samples

<table>
<thead>
<tr>
<th>Species</th>
<th>Triangulated nests</th>
<th>Untriangulated nests</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chelonia mydas</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eggshells</td>
<td>505</td>
<td>531</td>
<td>1036</td>
</tr>
<tr>
<td>Tissue</td>
<td>77</td>
<td>104</td>
<td>181</td>
</tr>
<tr>
<td>Total</td>
<td>582</td>
<td>635</td>
<td>1217</td>
</tr>
<tr>
<td>Eretmochelys imbricata</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eggshells</td>
<td>51</td>
<td>110</td>
<td>161</td>
</tr>
<tr>
<td>Tissue</td>
<td>24</td>
<td>44</td>
<td>68</td>
</tr>
<tr>
<td>Total</td>
<td>65</td>
<td>154</td>
<td>219</td>
</tr>
<tr>
<td>Caretta caretta</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eggshells</td>
<td>0</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Tissue</td>
<td>0</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>0</td>
<td>13</td>
<td>13</td>
</tr>
</tbody>
</table>

Human Impact

Human Impact was recorded every night in order to gain a better understanding of the illegal activity on Playa Norte during turtle nesting season. White lights were the most frequent human impact, with 690 records, representing the 40.35% of all the illegal activity (Table 17). The majority of these records occurred at mile 2 4/8, between the 20.00h and the 22.00h (Fig 25B and 26). The second impact in number of records was the presence of locals on the beach (28.65%, Table 17), most of them were found between 20.00h and 22.00h at miles 0 and 2/8 (Fig 25A and 26). For analysis, week 4 of each month contains dates 29 and more.

Table 17. Human impact observations in Playa Norte from March 29th to October 29th 2017.

<table>
<thead>
<tr>
<th></th>
<th>White lights</th>
<th>Cellphones</th>
<th>Red lights</th>
<th>Fires</th>
<th>Locals</th>
<th>Tourists</th>
<th>Dogs</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of observations</td>
<td>690 (40.35%)</td>
<td>57 (3.33%)</td>
<td>34 (1.9%)</td>
<td>490 (28.65%)</td>
<td>65 (3.8%)</td>
<td>330 (19.30%)</td>
<td>1710</td>
<td></td>
</tr>
</tbody>
</table>
Figure 24. Temporal distribution of (illegal) human activity by week – Bars indicate the total numbers of impacts encountered in each week (1-4) of a given month in Playa Norte from March 29th to October 29th 2017. A) From March until July and B) from July until October.
Figure 25. Spatial distribution of (illegal) human activity by mile—Bars indicate the total number of impacts encountered within the section of a given mile marker in Playa Norte from March 29th to October 29th 2017. A) From mile 0 to 1 4/8 and B) from mile 1 5/8 to 3 1/8. *Take into account the logarithmic scale of the vertical axis.
Figure 26. Temporal distribution of (illegal) human activity by hour – Bars indicate the total number of impacts encountered from minute 00 to 59 for each given hour. *Take into account the logarithmic scale of the vertical axis.

Light Survey

To gain a better understanding of artificial light use along the beach transect, monthly Light Surveys were conducted. These surveys provide data for mitigation strategies to reduce light on the beach that could negatively affect the nesting behavior of marine turtles. The hotel Turtle Beach Lodge, as well as Hotel Vista al Mar had the highest white and yellow bulb count. Similarly, the public lights in miles 2/8, 6/8 and 1 4/8 are clearly visible from the beach (Fig. 27).

Figure 27. Light Survey – Bars indicate the total number of permanent White and yellow lights located along the beach transect per month. *Take into account the logarithmic scale of the vertical axis
Beach Habitat Management

Marine Debris

Last year we began a standardized survey for marine debris, according to NOAA protocols (Lippiat, et al., 2013). This is to ensure comparability with other marine debris monitoring projects around the world following the same protocols. We have a 100m transect, which continues to the most recent high tide line (usually approx. 50m), just south of the river mouth of Laguna Tortuguero. Each month the debris transect is completely cleaned of all meso, macro, and mega debris (essentially, all debris larger than 2.5cm on any one side) each month, in order to examine the flux of land based and sea-based debris. As marine debris, and plastics in particular have been a documented hazard to all species of sea turtles, in all life stages (Schuyler et al., 2014), the information gathered from this study will likely prove an invaluable companion dataset to compare to nesting activity and nest success throughout the season. This survey will run for a minimum of one year. A summary of the findings through the first four months can be viewed below.

**Table 18.** Total number of marine debris items by month 2017

<table>
<thead>
<tr>
<th>Items</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plastics</td>
<td>8,615</td>
<td>12,053</td>
<td>12,696</td>
<td>9,039</td>
<td>3,947</td>
<td>3420</td>
<td>12987</td>
<td>4121</td>
<td>854</td>
</tr>
<tr>
<td>Plastic fragments</td>
<td>1,464</td>
<td>4,539</td>
<td>7,674</td>
<td>6,093</td>
<td>1,196</td>
<td>1728</td>
<td>7328</td>
<td>2352</td>
<td>537</td>
</tr>
<tr>
<td>Metal</td>
<td>30</td>
<td>58</td>
<td>29</td>
<td>25</td>
<td>15</td>
<td>15</td>
<td>44</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>Glass</td>
<td>69</td>
<td>46</td>
<td>39</td>
<td>12</td>
<td>7</td>
<td>6</td>
<td>58</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>Rubber</td>
<td>72</td>
<td>108</td>
<td>78</td>
<td>41</td>
<td>47</td>
<td>29</td>
<td>121</td>
<td>12</td>
<td>5</td>
</tr>
<tr>
<td>Processed lumber</td>
<td>90</td>
<td>168</td>
<td>481</td>
<td>239</td>
<td>255</td>
<td>34</td>
<td>510</td>
<td>225</td>
<td>51</td>
</tr>
<tr>
<td>Clothes/ Fabric</td>
<td>91</td>
<td>116</td>
<td>87</td>
<td>19</td>
<td>33</td>
<td>19</td>
<td>106</td>
<td>45</td>
<td>3</td>
</tr>
<tr>
<td>Others</td>
<td>0</td>
<td>16</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>8967</td>
<td>12,565</td>
<td>13,412</td>
<td>9,378</td>
<td>4,310</td>
<td>5,529</td>
<td>21,155</td>
<td>4,447</td>
<td>917</td>
</tr>
</tbody>
</table>

Collaboration, outreach and public education

Working with stakeholders and the local community is crucial to the success of the program, therefore in the Caño Palma Biological Station we are consistently looking to participate in activities that involve the community as well as other institutions and organizations that work in the region. At the beginning of March, the field and outreach coordinators from the Sea Turtle Conservancy (STC), Jaime Restrepo and Silvia Arriscado, accompanied by the leatherback season research assistants, made us a visit to know the station and to learn more about our projects, this was a good opportunity for our interns and volunteers to do some network and to share experiences with members of other organizations.

At the beginning of May National Park invited us to participate in the development of the Archie Carr Wildlife refuge management plan, we are very happy to collaborate with them. There is an opportunity to develop these area as a tourist and wildlife corridor, between the National
Park and the Cerro, and this might imply the creation of more opportunities in our community to improve the life quality of the habitants as well as more participation of the authorities in the area.

This year the refreshing week for the guides of Tortuguero happened from May 29th to June 2nd in the Tortuguero National Park headquarters, we were invited and we gladly participated, we shared information about our projects and recent results, we could also exchange information with other organizations such as STC, GVI Jalova and Coastal Jaguar Conservation.

In August we celebrated the Macaw Festival in the community of San Francisco, which served as a forum for local researchers to disseminate the results obtained recently in field studies, it was also a great opportunity for the community to learn more about the status of the population of green and scarlet macaws in the region.

In the month of February 2018 our organization, and in particular the turtle program was successfully represented at the 38th International Symposium on Sea Turtle Biology and Conservation with two research presentations. Proudly the work of our PhD student Helen Pheasey, on the use of decoy eggs to track poaching activities, won an Archie Carr award for such research.

Commitment with the community

This year Playa Norte lost the Bandera Azul certification, due to the lack of participation in beach cleanings and the lack of concern from the authorities about the water quality of our river and beach. Therefore we got involved in helping the community to get the certification back. Some of the activities where we have participated are acn cleanings; the students from Shawnee State University and Nature Expeditions helped us to clean the most visited part of the beach, close to the river mouth of the Tortuguero River. Other related activities were the environmental education talks given in the elementary school of San Francisco.

Conservation Club

Conservation club is an extracurricular activity available to students of Escuela Laguna Tortuguero, held on Fridays at the COTERC community library in the village of San Francisco, in April and May. Activities included discussions about nature conservation and ecology. The goal is to encourage environmentally friendly attitudes in the youth of San Francisco, and to develop the habit of taking care of nature since early ages. The development of this club depends on the presence of community interns in the station, thus is not a permanent activity.

Volunteers and Interns

Between March 1st and November 30th, a total of 66 volunteers and 23 interns were trained in how to work a turtle using our protocols (Table 19). In total, seven people qualified for patrol leader training (with a grade over 95%), and five of them demonstrated the practical skills to become patrol leaders and took teams out on the beach at night.
Table 19. Volunteers and interns trained in the green and hawksbill season 2017.

<table>
<thead>
<tr>
<th>Volunteer/intern</th>
<th>Country</th>
<th>Association</th>
<th>Number</th>
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<tbody>
<tr>
<td>Volunteer</td>
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<td>Nature Expedition</td>
<td>9</td>
</tr>
<tr>
<td>Volunteer</td>
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</tr>
<tr>
<td>Intern (Master student)</td>
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<td>University of West Antilles</td>
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<tr>
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<td>Wageningen University and Research</td>
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<td>Van Hall Larenstein</td>
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<tr>
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<td>2</td>
</tr>
<tr>
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<tr>
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</tr>
<tr>
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<td>Intern (PhD student)</td>
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<tr>
<td>Intern (Turtle)</td>
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</tr>
<tr>
<td>Intern (Community)</td>
<td>Mexico</td>
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<tr>
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</table>
Discussion

The beginning of the 2017 season was atypical, historically is considered May 1st, but the first green nest recorded this year happened in March 24th. In the other side the peak activity patterns maintained what historically has been recorded, which was the last week of August, the end of the season was a bit earlier than previous years, with a decrease of turtle activity in October and only a few events in November and December.

Effort

The survey effort increased gradually along the season, depending on the available personnel to carry out the night patrols. For the first two weeks of surveys, due to the amount of personnel available, it was only possible to patrol the beach with one team. The presence of more volunteers and interns allowed us to patrol the beach with two teams for several occasions in the second part of April (n=9), most of May (n=8) and June (n=13). The first week of May and June the personnel available decreased so the patrols were reduced to only one, but the second week of May and the third of June we were able to patrol with three teams due to the availability of interns and volunteers.

Unfortunately after the second week of August and during the peak of nesting activity we only had one patrol on the beach, what made difficult for us to obtaining as much information as we could about the females nesting on the beach. Towards the end of the season our low number of personnel did not allow us to continue with the daily patrolling of our beach, what also implied loss of information.

Nesting activity

In the months of May and June hawksbill turtles accounted for most of the nesting events, starting July the green turtles activity became more numerous. The total number of green turtle nests recorded this season (n=333) represented a decrease of 37.4% with respect to 2016 (n=532, McCargar & Humphreys, 2016), but represented an increase of 137.6% if compared to the activity of 2015 (n=242, McCargar & Pheasey 2015).

In the case of hawksbill turtles, this year were recorded the highest number of nests that have occurred in Playa Norte since the beginning of the monitoring program in 2006, with 71 nesting events, representing an increase of 197.22% over the previous year (n=36, McCargar & Humphreys, 2016) and an increase in activity of 208.82% when compared to 2015 (n=34, McCargar & Pheasey 2015).

A nesting event of a loggerhead turtle (Caretta Caretta) was successfully registered this year, which had not been recorded with complete certainty since 2006. Fortunately, we were able to tag the turtle, triangulate the nest, excavate it, and take genetic samples from it successfully, which gives us valuable information about the population of loggerhead turtles that rarely nest in the area.
**Nest success**

This season 44.62% (54 out of 121) of the triangulated nests suffered some type of affectation, either a complete or partial depredation, as well as a complete or partial poaching. These threats could be avoided and/or reduced to ensure the survival of this species, if the activity and presence of domestic animals on the beach were regulated, as well as reducing the hunting and poaching of turtles by locals and foreigners for their consumption.

On the other hand, 52.06% (63 out of 121) finished their incubation process successfully, which meant an important source of information for our database regarding incubation periods as well as hatching and emergency successes, especially the amount of data we could get this year about hawksbill turtles.

This year we had a few days of considerable high tide at the end of October, but fortunately this did not represent a significant impact on the development of the affected nests. This indicates that even when the temperature of the nests can be affected by the presence of water, this does not mean they will be seriously affected if such an event happens.

**Human Impact and Light Survey**

The majority of impacts belong to the presence of white lights on the beach during non-permitted hours, most of these are recorded in mile 2 4/8, where the security guard of Turtle Beach Lodge and the guests go out on the beach after 18.00h either to look for cellphone reception or just to have a walk on the beach. The remaining impacts coincide with the inhabited parts of the beach, both the number of lights and the presence of people. Dogs can also be found mostly around the inhabited zones but they present mobility through the whole beach.

We recorded an important increase in activity during Holy Week compared to the rest of the season, and we recorded an increase in human activity on weekends, particularly on Saturdays followed by Fridays. Therefore, if there were the possibility of having a police presence, we would suggest these two days to reduce the impact on the nesting activity.

The data of Light Survey was consistent every month, except for some lights that are not permanently lit in some points of the beach, this indicates us that there is no great change in the number of fixed lights in the path of the beach.

**Possible improvements to the program**

To guarantee a better protection to the turtles while they nest, it would be a great help for us to have the police presence on the beach regularly, we noticed an increase on the poaching activity on the beach, which decrease immediately when the police made a presence on the beach.

For the nest protection, is necessary to use another material than bamboo, something like metal grids, in order to make the protection barriers more stable and harder to break, this could completely prevent predation events in nests, or at least could be more resistant to the attacks by predators.
Bibliography


